PIEZOELECTRIC ACTUATOR

Background of the Invention ~~Prior Art~~

~~The invention concerns a piezoelectric actuator, e.g., to actuate a mechanical~~ component such as a ~~valve or the like~~, according to the features—based on the ~~general class of the primary claim.~~

It is generally known that, by utilizing the "piezoelectric effect", a piezoelectric element can be constructed out of a material having a suitable crystal structure. When an external electrical voltage is applied, a mechanical reaction of the piezoelectric element takes place that, depending on the crystal structure and the application regions of the electrical voltage, represents a push or pull in a specifiable direction. The construction of this piezoelectric actuator can take place here in a plurality of layers (multilayer actuators), and each of the electrodes, via which the electrical voltage is applied, is arranged between the layers. When the piezoelectric actuator is operated, care must be taken to ensure that no disturbing crack formations develop in the ply structure by means of mechanical stresses.

Summary of the Invention ~~Advantages of the Invention~~

The piezoelectric actuator described initially, which can be used to actuate a mechanical component, for example, is advantageously constructed with a multilayer structure of piezoelectric plies and electrodes arranged between them. With a lateral contacting of the electrodes in alternate directions, a neutral phase forms in the region between two piezoelectric plies in each case. Since the electrodes contacted on one side in each case are integrated in the ply structure in the manner of a comb, the consecutive electrodes in the direction of the ply build-up must be contacted on opposite sides, always in alternating fashion.

As a rule, the electrodes contacted on one side can thereby not always be extended completely to the opposite side, because voltage spark-overs could otherwise lead to the destruction of the piezoelectric actuator. When the piezoelectric actuator is operated, i.e., when a voltage is applied between the opposing electrodes in the ply structure, different mechanical forces occur in the region of the electrodes as well as in the non-contacted neutral phases, which can lead to mechanical stresses and crack formations in the piezoelectric actuator.

In an advantageous exemplary embodiment according to the invention, one electrode layer of the internal electrode that is contacted on one side is always extended completely to the end of the other side at specified intervals, and the external electrode lying on the other side in each case thereby bridges over this layer to prevent a short circuit. The contacting in alternate directions is constructed in such a fashion that two internal electrodes—that enclose an internal electrode having the opposite polarity and contacted on the opposite side—are contacted jointly on one side in each case. In alternating fashion, one of these jointly contacted internal electrodes—with formation of a neutral phase—is now not extended to the end of the piezoelectric plies in each case, and the other is extended to the end of the piezoelectric ply in each case.

A contacting with external electrodes is possible in which an insulation layer is applied in simple fashion in the region in which the other internal electrode extended on the non-contacted side to the end lies. The external electrodes can thereby be composed of an electrically conductive screen or net. The form of the external electrode can also be a simple metal strip here, and this can be composed of a conductive material with similar coefficients of thermal expansion as the ceramic material of the piezoelectric plies, e.g., invar.

In another preferred embodiment, however, the external electrodes are advantageously wave electrodes that bridge over the other internal electrode—

extended to the end of the piezoelectric ply and not to be contacted—at a specified distance in the shape of a wave.

With the exemplary embodiments named previously, it is therefore possible to extend every other internal electrode to the outside via partial external contacting. With this measure and a partially offset external electrode, e.g., a wave electrode which is connected only in the region of the external contacting and which has a distance of approximately 50 μm, for example, from the internal electrode not to be contacted, a short circuit can be avoided here and the expansion in the external region—by the reduction of the neutral phase—can be increased markedly overall, so that the risk of crack formation is reduced.

It is furthermore advantageous when the multilayer structure of the piezoelectric plies is provided with an electrically insulating ceramic plate on each end of the folded layers.

These and further features of preferred further developments of the invention also arise from the description and the diagrams in addition to the claims, and each of the individual features can be realized on its own or in plurality in the form of sub-combinations in the exemplary embodiment of the invention and in other fields, and can represent advantageous and patentable embodiments in themselves, for which protection is claimed here.

Brief Description of the Drawings

~~Diagram~~

Exemplary embodiments of the piezoelectric actuator according to the invention are explained using the diagram.

Figure 1 shows a sectional view through a piezoelectric actuator with a multilayer structure of plies composed of piezoelectric ceramic and having contacted

internal electrodes in alternate directions and external electrodes designed in the shape of a wave;

Figure 2 shows a side view along the line A-A of Figure 1, and

Figure 3 shows a partial sectional view of an exemplary embodiment having insulated regions in the region of each non-contacted internal electrode extended toward the outside.

Description of the ~~Exemplary~~ Preferred Embodiments

A piezoelectric actuator 1 is shown in Figure 1 that is constructed in a fashion known per se out of piezoelectric films 2 of a quartz material having a suitable crystal structure, so that, by utilizing the "piezoelectric effect" when applying an external electrical voltage to internal electrodes 3 and 4 as well as 5 and 6, etc. by way of external electrodes 7 and 8 contacted externally, a mechanical reaction of the piezoelectric actuator 1 takes place.

It is furthermore obvious in Figure 1 that the external electrodes are designed as wave electrodes 7 and 8 that are always contacted at contact surfaces 9 and 10 with two internal electrodes having the same polarity. Every other internal electrode 3, 5 or 4, 6 having the same polarity in each case is continuous to the other end of the piezoelectric actuator 1 and is hereby insulated from this by means of a wave 11 of the respective external electrode 7 and 8 not to be contacted.

One electrically insulating head plate 12 and one foot plate 13 each are also applied to the external piezoelectric plies of the films 2, by means of which the entire piezoelectric actuator 1 can be insulated toward the outside.

To illustrate the exemplary embodiment according to Figure 1, a side view along A-A from Figure 1 is shown in Figure 2, in which a top view of the external

electrode 8 can be seen. The same components are labelled with the identical reference numerals here.

A second exemplary embodiment of a piezoelectric actuator 1 having another external contacting 16 is shown in Figure 3. A simple metal foil 14 is available here as the external electrode, which touches an insulation layer 15 applied in-between in the region of the internal electrodes 5, etc. not to be contacted. The same effect can therefore be achieved as in the exemplary embodiment according to Figures 1 and 2.